PHOTOGRAPHY IN THE TECHNOLOGY OF EXPLOSIVES.

By ALFRED SIERSCH.

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In consequence of the frequent occurrence of accidents in coal-mines of recent years, various countries have increased the strictness of existing regulations relating to blasting and inspection, and have also delegated to commissions the task of elucidating the causes and best methods of preventing explosions in fiery mines. Experts have, however, been engaged for a considerable period in attempting to devise, from the results of experiments, measures suited for increasing the safety of mining operations.

Photography has already been of great service to science, but up to the present has only found limited employment in the technology of explosives.

The flash resulting from the ignition of explosives is well known to exhibit variations in intensity, etc., but observers have been content to recognize the fact without bestowing further attention thereupon ; indeed, it is not easy to determine, in the case of a flash lasting only a small fraction of a second, whether it is comparatively large or small, there being many external circumstances, such as the distance of the observer from the spot where the explosion occurs, the nature and size of the charge, the degree of darkness, fog, etc., which influence the observation to a considerable extent. The writer agrees with those experts who are of opinion that the safety of an explosive appears to increase in proportion as the flash decreases, and in order to measure the latter and to be able to determine its nature and intensity, he has endeavoured, by means of photographs of the various phenomena, to collect material for an effective method of comparison. The photographic plates obtained showed such surprising results that he has no hesitation in stating that photography is calculated to be of great service in the technology of explosives. Photography affords a better means of determining the nature and manner of the decomposition of the explosive than either analysis or ignition-tests, excluding, moreover—when carefully employed—all risk of error. Photography shows undoubtedly that the different explosives give different plates, and that each variety is characterized

by its distinctive flash, this being especially manifested by the photographic pictures obtained in the case of two different explosives suspended one above the other and ignited simultaneously.

This fact by itself indicates a certain regularity of decomposition and invites one to a closer investigation. To the expert, it foreshadows the possibility of obtaining a clearer insight into the value of an explosive material, it being important to him to ascertain in the quickest manner the action of the individual constituents, the correctness of the method of preparation, and the influence of the different mixtures. To the mining engineer it will afford a ready means for convincing himself in the simplest manner of the relative security of the explosives employed, as few collieries are provided with an experimental gallery suitable for making experiments with explosives, and, moreover, such tests occupy much more time than is required for taking a photograph.

We are now, undoubtedly, only in the early stages of the new method of testing, but it is one that, as in other instances, will certainly undergo important developments and extensions in a comparatively short time.

As soon as the experiments now progressing in an experimental gallery have confirmed the accuracy of the writer's researches, the methods of testing explosives, now varying in individual experiments, will attain the uniformity that their importance requires.

On the basis of the investigations made up to the present time, the following conclusions may be considered as proved :—

a. The flashes produced by the ignition of various explosives are not identical : the smaller the flash the greater the relative security of the explosive. Figs. 1 to 16 (Plates I. and II.) are pictures exhibiting the results of igniting 3·53 ounces (100 grammes) of each of the following explosives in freely suspended cartridges :—

Fig. 1.—Nitro-glycerine.
„ 2.—Gun-cotton.
„ 3.—Nitro-starch.
„ 4.—Hellhoffit.
„ 5.—Blasting-gelatine.
„ 6.—Gelatine-dynamit I.
„ 7.— „ „ II.
„ 8.—Guhr-dynamit.

Fig. 9.—Roburit.
„ 10.—Carbonit.
„ 11.—Wetter-dynamit.
„ 12.—Westfalit.
„ 13.—Dahmenit.
„ 14.—Grisoutine.
„ 15.—Grisoutit.
„ 16.—Progressit.

Figs. 17 to 22 (Plate III.) show the flashes of blown-out shots of 100 grammes each of gelatine-dynamit I. stemmed with wet paper (Fig. 17), guhr-dynamit (Fig. 18), roburit (Fig. 19), antigrisou (Fig. 20), wetter-dynamit (Fig. 21), and progressit (Fig. 22).

Bergassessor Winkhaus states* that the following minimum charges sufficed to ignite mixtures containing 6·5 to 7 per cent. of pit-gas :—

	Ounces.		Grammes.
Gelatine-dynamit	1·76	...	50
Guhr-dynamit	2·05	...	58
Roburit	5·43	...	154
Westfalit	8·85	...	251
Dahmenit	8·85	...	251
Progressit	19·40	...	550

A casual inspection of the flash-pictures from these explosives will confirm what has been advanced under this section.

b. Other conditions being equal, each explosive gives a similar flash. The proof of this statement is afforded by the views of the flashes of freely suspended and simultaneously ignited double cartridges of 3·53 ounces (100 grammes) each of : gelatine-dynamit I., Fig. 23 (Plate IV.), roburit (Fig 24), wetter-dynamit (Fig. 25), and progressit (Fig. 26).

In order to ensure the safety of the camera, the double cartridges of gelatine-dynamit I. were exploded further distant than the others, which accounts for the picture being smaller than that in Fig. 6 (Plate II.). Between the roburit and wetter-dynamit cartridges a luminous zone of glowing gases is distinguishable (Figs. 24 and 25, Plate IV.).

c. The shape and dimensions of the flashes afford a clue to the eventual security of the explosives. Figs. 27 and 28 (Plate V.) show the flashes from 3·53 ounces (100 grammes) of guhr-dynamit in a caoutchouc envelope or water-cartridge, and 3·53 ounces (100 grammes) of guhr-dynamit under water (in a glass-beaker). Also a blown-out shot of 3·53 ounces (100 grammes) of gelatine-dynamit (Fig. 29, Plate V.) with moist paper stemming. Comparison of these pictures with Figs. 6 and 8 (Plate II.) confirms beyond contradiction the well-known fact that both by the water-cartridge and water-tamping, even highly dispersive explosives can be rendered safe. This is also the case with moss-tamping, as the views taken at the instance of Mr. Franz Brzezowski have shown.

d. Under otherwise identical conditions, the degree of security of an explosive decreases as the diameter of the cartridge (and the consequent size of the flash) is increased. Fig. 30 (Plate IV.) shows the flash given by 10·58 ounces (300 grammes) of progressit, in a cartridge 1·38 inches (35 millimetres) in diameter, and Fig. 31 that of 10·58 ounces (300 grammes) of the same explosive in a cartridge 1·97 inches (50 millimetres) in diameter.

e. The flash from an explosive varies—other circumstances being equal—with the density. This statement permits of conclusions being

* *Trans. Fed. Inst.*, vol. ix., page 263.

drawn respecting the greater or smaller explosibility of a blasting material. Figs. 32 and 33 (Plate IV.) display the flashes from 3·53 ounces (100 grammes) each of antigrisou of 1·20 and 0·90 densities respectively.

f. It is possible, by various admixtures, to increase or diminish the flash, the relative security of the particular explosive being correspondingly increased or diminished. Thus 3·53 ounces (100 grammes) of the following explosives gave the pictures indicated :—

Roburit, with admixture	Fig. 34,	Plate	V.
„ alone	„ 9,	„	I.
Grisoutine, with admixture	„ 35,	„	V.
„ alone	„ 14,	„	II.

g. An increase in the length of the unstemmed portion of the bore-hole decreases—under otherwise equal conditions—the security of the blown-out shot. This observation has been already recorded by other investigators, and is now confirmed by the aid of photography. Fig. 36 (Plate V.) shows the result of the ignition of 3·53 ounces (100 grammes) of gelatine-dynamit I., with an unstemmed length of 17·72 inches (45 centimetres) borehole, and Fig. 37 the same explosive and charge with an unstemmed length of 5·51 inches (14 centimetres). The first experiment was made at the suggestion of Mr. Fr. Brzezowski.

h. The size of the flame increases with the weight of the charge of explosive. This statement is confirmed by experiments with blown-out shots containing 3·53 ounces (100 grammes), 7·05 ounces (200 grammes), and 10·58 ounces (300 grammes), and views of the results are shown in Figs. 38, 39, and 40 (Plate VI.) respectively.

i. The well-known fact that explosives with a nitrate-of-ammonium basis become safer in the presence of fire-damp in proportion as their carbon constituents decrease is exemplified by Figs. 41 to 44 (Plate VI.). The smallest flash was given by an explosive containing 6 per cent., and the largest by one having 18 per cent. of the same carbon compound in association with nitrate of ammonium. The intermediate pictures are from explosives containing 8 and 12 per cent. of the same carbon compound.

k. Even when the blasting-cartridge is situated in an inconvenient position with reference to the sensitized plate the flashes from so-called safety-explosives are smaller than those from high explosives. Figs. 45 to 48 (Plate VI.) show the flashes from freely suspended blasting-cartridges of gelatine-dynamit I., roburit, wetter-dynamit, and progressit, with the mouth of the cartridge turned away from the sensitized plate.

The remark "under otherwise identical conditions" implies that the composition and preparation of the explosive is identical, *i.e.*, the

quantity of explosive, length, diameter, density, and cover of the cartridge, and the strength of the initial detonation require adjusting with the greatest care. The camera must, of course, be placed at a constant distance from the spot where the explosion is produced, and the plates employed, whether lumière, eosin, cyanin, or any other kind, must be of the same degree of rapidity.

From the foregoing remarks, it appears that photography affords unusually great assistance in the determination of the nature and action of explosives, by enabling the relative degree of security to be quickly ascertained, and indicates to the technologist the manner (so far as composition is concerned) and method of preparing new explosives. It affords also an insight into the effect of various modes of stemming, and is, therefore, an aid that should certainly not be underestimated in the technology of explosives.

Mr. A. H. Stokes (H.M. Inspector of Mines, Derby) asked whether the author could supply the members with particulars as to how these beautiful photographs had been taken? He would like to know what description of sensitized plates had been used for the purposes of the photographs, where the camera was placed, and other details of manipulation. The experiments on explosives made by a committee of the North of England Institute of Mining and Mechanical Engineers were interesting, but it would have been better if (instead of depending on the eyesight) they had obtained permanent photographic records, similar to the photographs exhibited by Mr. Siersch, as to whether flame was produced or not. He noticed that the flame produced by blasting-powder had not been recorded; it would have been interesting if Mr. Siersch could have given them a record. Mr. Siersch gave them the interesting fact that the water-cartridge was safe. He also made the curious statement that the degree of security of an explosive decreased as the diameter of the cartridge (and the consequent size of the flash) was increased. He (Mr. Stokes) would like to know whether any attempts had been made to photograph the flame of detonators, because with a very small cartridge the flame registered would probably not be the flame of the explosive but the flame of the detonator.

Mr. M. Deacon (Blackwell) said that the members had records of experiments with coal-dust and experiments to show the power of various explosives. These had helped the members to a considerable extent,

but he would like to know whether, by means of photography, they could ascertain the relative intensities of the flames produced by various explosives.

Mr. ALFRED SIERSCH (Pressburg, Hungary) wrote that the photographs of the luminous phenomena resulting from the detonation of various explosives were taken on dark nights, in the following manner :—The suspended cartridge *I* (Fig. 49), which is intended to be detonated, having, as a rule, a diameter of 1·38 inches (35 millimetres), and a length varying between 3·94 and 5·12 inches (100 and 130 millimetres), is

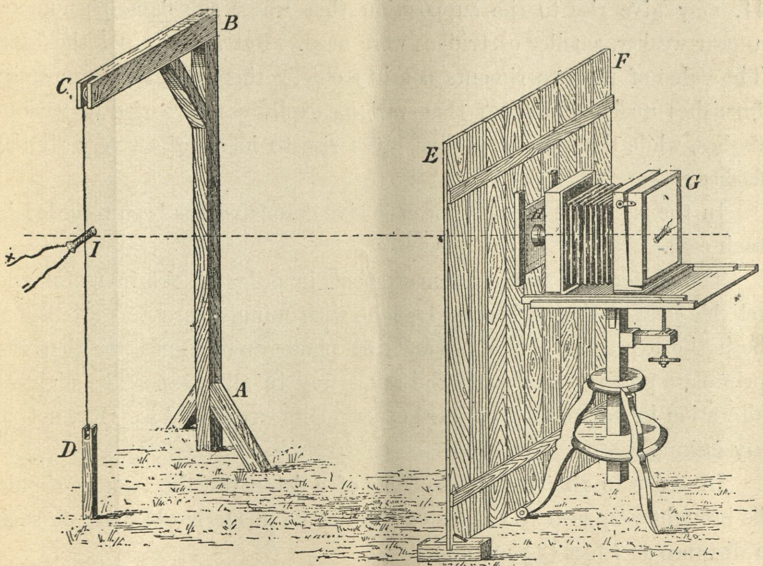

Fig. 49.

secured to a wooden framework *A B C*, by a copper wire *C D*, in such wise that the whole length of the illuminated cartridge is clearly seen in the camera. The electric detonator (No. 8), which has already been fixed in the cartridge, and contains 30·86 grains (2 grammes) of fulminate, is connected to the magneto-electric exploder, about 150 feet distant. In this way, the position of the cartridge remains unaltered.

The camera *G*, provided with a lens about $4\frac{1}{2}$ inches (115 millimetres) in diameter, is placed 7·22 feet ($2\frac{1}{5}$ metres) distant from the suspended cartridge. It is protected by a strong wooden partition *E F*, wherein a hole is pierced for the lens; the latter is in turn shielded by a glass plate placed in front of it. These preparations being completed, the source of illumination is removed, the sensitive plate is placed in the camera, and the shot is fired.

In the case of blown-out shots, a cylindrical steel cannon is used, the dimensions of which are:—Height, 31·50 inches (800 millimetres); diameter, 21·65 inches (550 millimetres); the depth of the borehole being 18·11 inches (460 millimetres); and the diameter of the borehole, 2·16 inches (55 millimetres). The steel cannon is placed in a perpendicular position, and is sunk in the earth up to its topmost edge. In the course of these experiments, the camera is placed at a distance of 4·92 feet ($1\frac{1}{2}$ metres) from the bore of the cannon.

The views shown as successively smaller and smaller in Plates I. and II. may give rise to the supposition that where the flame-phenomena appear weaker, smaller cartridges were used. But such is not the case. The value of the experiments consists chiefly therein that photography furnishes undeniable proof that various explosives give rise to various flashes, while the same explosive gives rise to identical or very similar flashes.

In the paper the quantity of explosive detonated has been recorded in each case.

The writer may further remark that, in order to obtain useful and reliable images, the work must be done with minute care and attention; both the expert in explosives and the photographer must see that the prints are prepared in exactly the same way in all cases. The slightest alteration in the conduct of these experiments would lead to error, not to say failure.

In order to photograph the flame of a detonator, the camera should be brought very near to the last-named, as no image is obtained at such a distance as 7 feet ($2\frac{1}{5}$ metres).

He (Mr. Siersch) thanked the members of the Institution for the distinction accorded to him, and remained at the disposal of the members for further explanations. Blasting-powder had not been included within the scope of the researches, because he was unacquainted with its composition.

The CHAIRMAN, in adjourning the discussion, said that Mr. Siersch's photographs were very beautiful; he believed that considerable difficulties had been experienced in taking and printing them, and hoped that they could be reproduced in the *Transactions*. He moved that the thanks of the members be accorded to the author for his interesting paper.

The resolution was agreed to.

Fig. 1. Nitro-glycerine, 3.53 ounces.

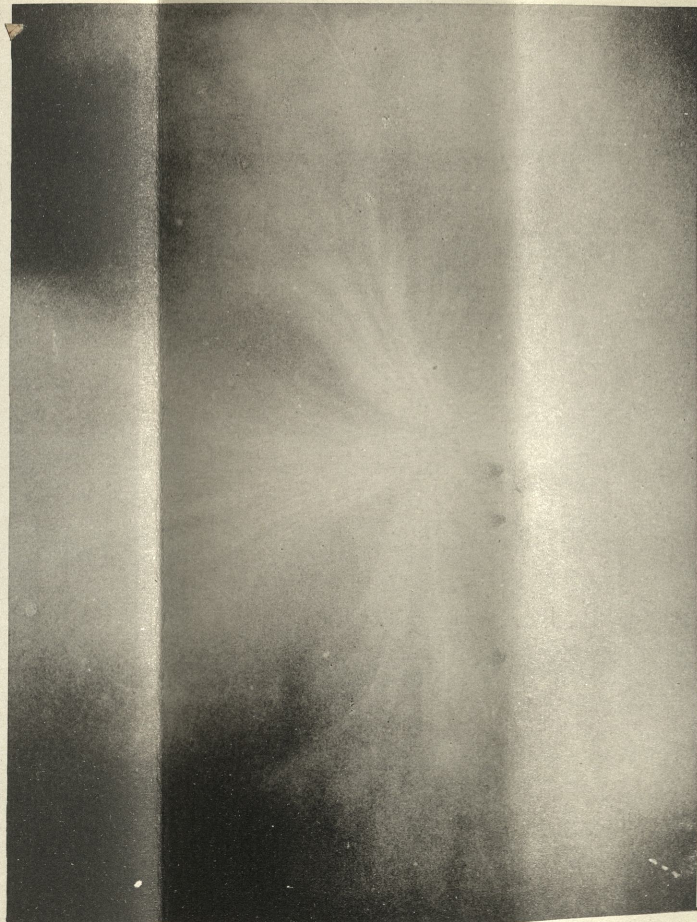

Fig 2. Gun-cotton, 3.53 ounces.

Fig. 3. Nitro-starch, 3·53 ounces.

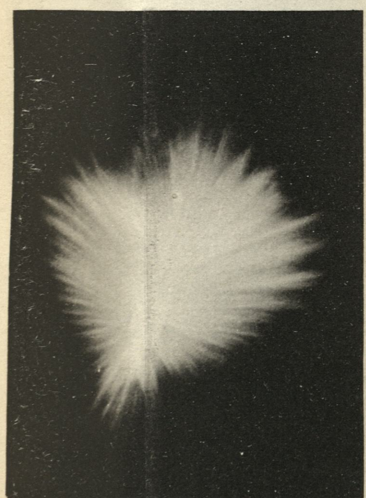

Fig. 9 Roburit, 3.53 ounces

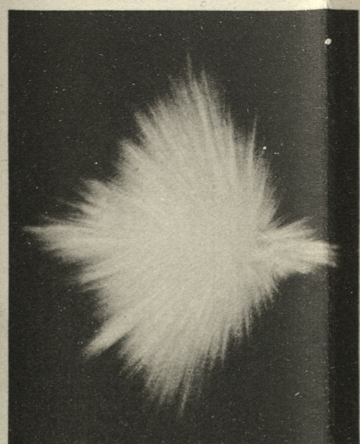

Fig. 10. Carbonit, 3.53 ounces.

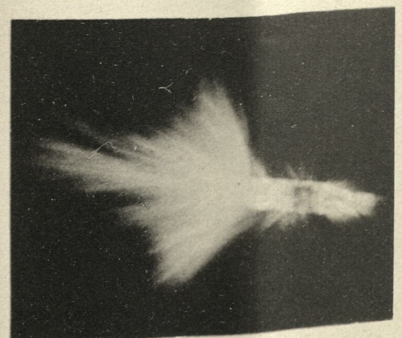

Fig. 11. Wetter-Dynamit, 3.53 ounces

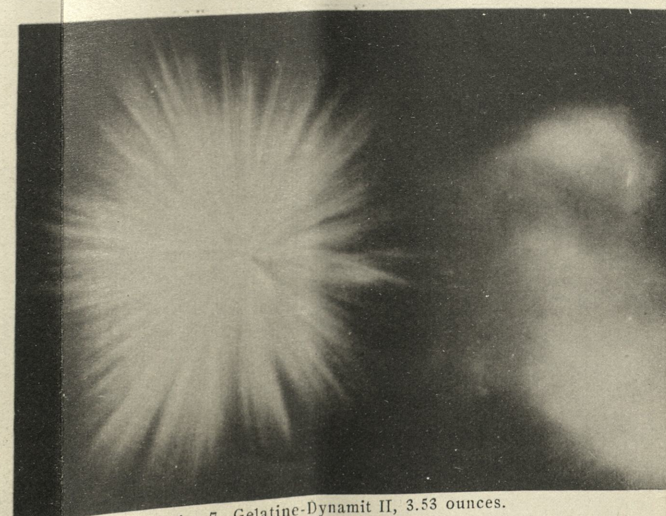

Fig. 7. Gelatine-Dynamit II, 3.53 ounces.

Collotype Print by M. Jaffé, Vienna.

To illustrate Mr. A Siersch's Paper on "Photography in the Technology of Explosives."

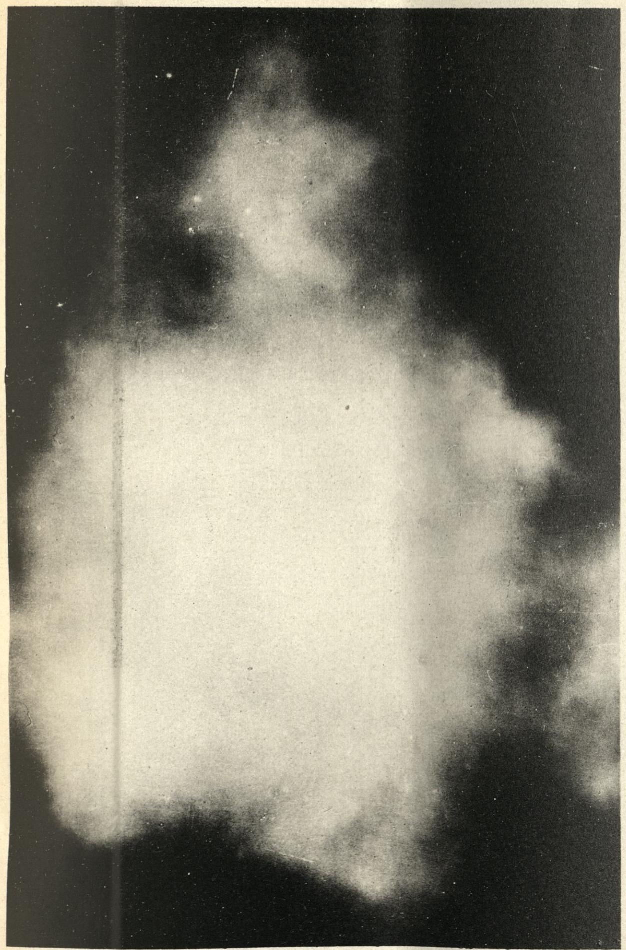

Fig. 5. Blasting-gelatine, 3.53 ounces.

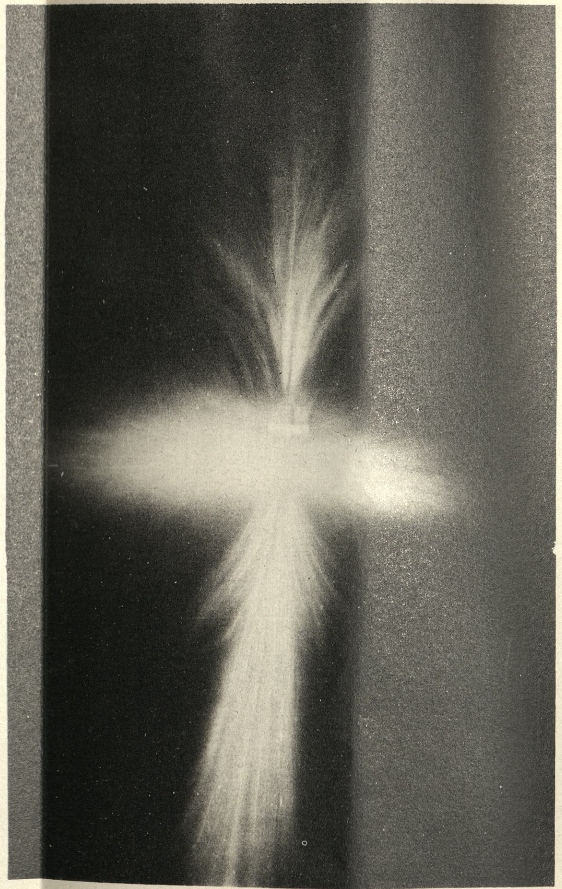

Fig. 4. Hellhoffit, 3.53 ounces.

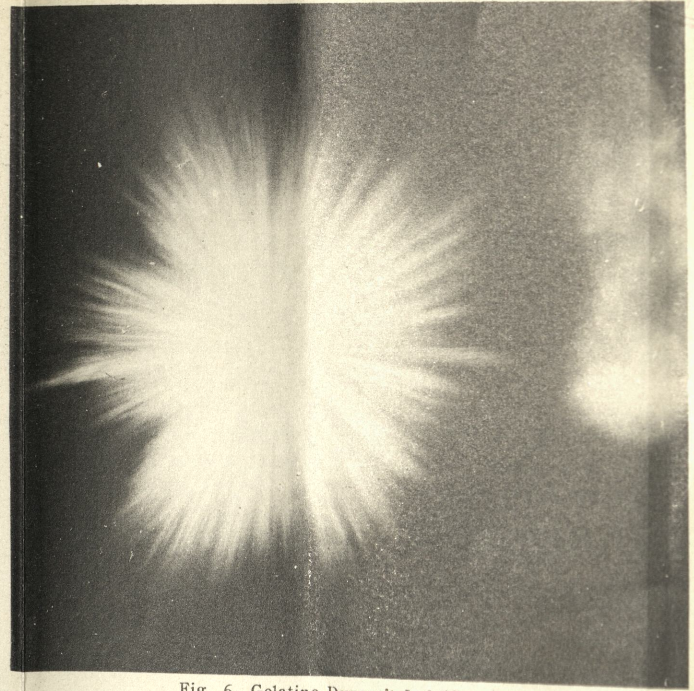

Fig. 6. Gelatine-Dynamit I, 3.53 ounces.

Fig. 12. Westfalit, 3.53 ounces.

Fig. 13. Dahmenit, 3.53 ounces.

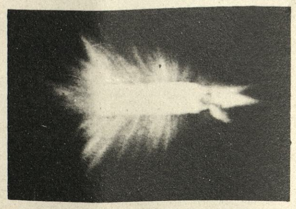

Fig. 14. Grisoutine, 3.53 ounces.

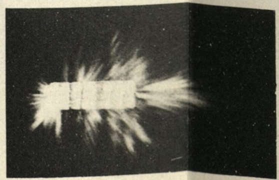

Fig. 15. Grisoutit. 3.53 ounces.

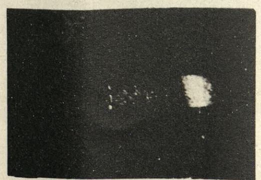

Fig. 16. Progressit, 3.53 ounces.

Fig. 8. Guhr-Dynamit, 3.53 ounces.

Collotype Print by M. Jaffé, Vienna.

Fig. 17. Gelatine-Dynamit I, 3.53 ounces, stemmed with wet paper, blown-out shot.

Fig. 20. Antigrisou, 3.53 ounces, blown-out shot.

Fig. 19. Roburit, 3 53 ounces, blown-out shot.

Fig. 21. Wetter-Dynamit, 3.53 ounces, blown-out shot.

Fig. 22. Progressit, 3.53 ounces blown-out shot.

Fig. 18. Guhr-Dynamit, 3.53 ounces, blown-out shot.

Collotype Print by M Jaffé, Vienna.

To illustrate Mr. A. Siersch's Paper on "Photography in the Technology of Explosives."

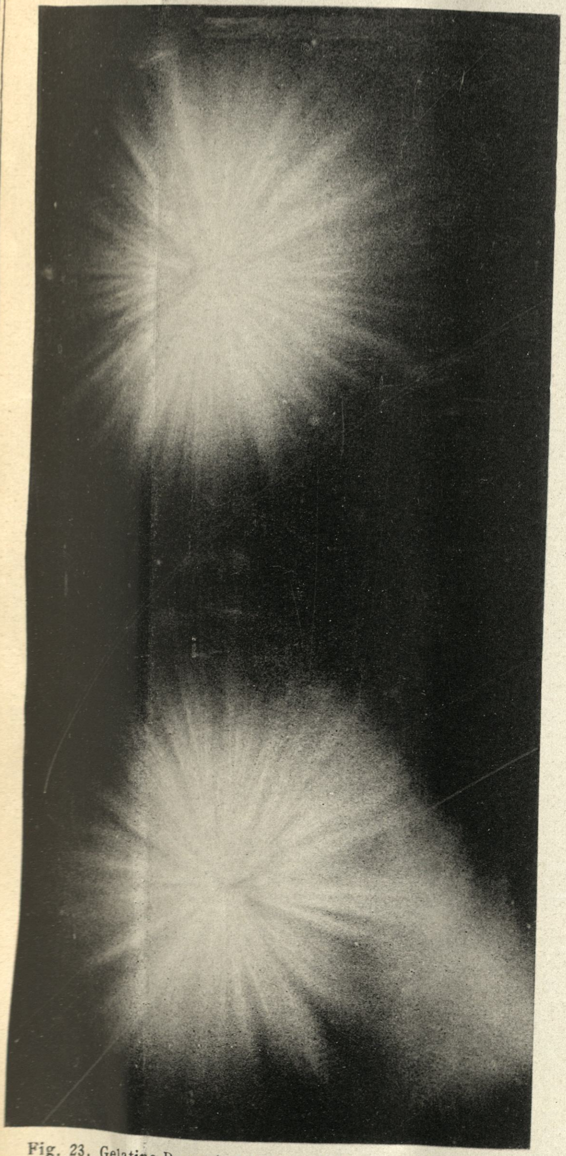

Fig. 23. Gelatine-Dynamit I, two cartridges of 3.53 ounces each, fired simultaneously.

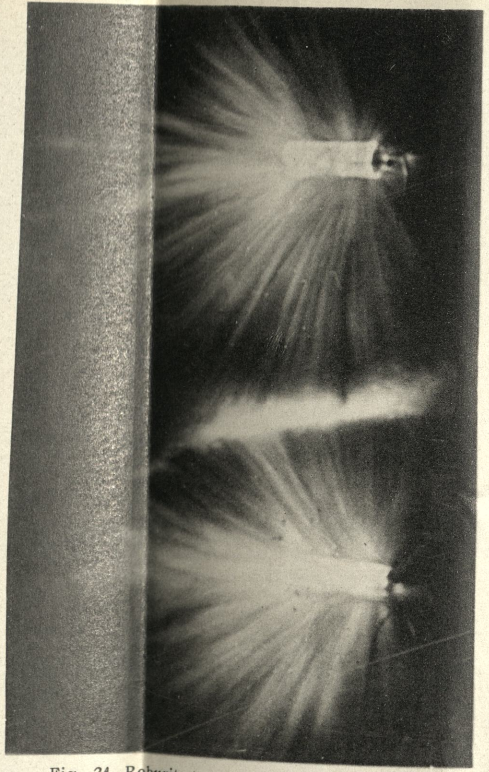

Fig. 24. Roburit, two cartridges of 3.53 ounces each, fired simultaneously.

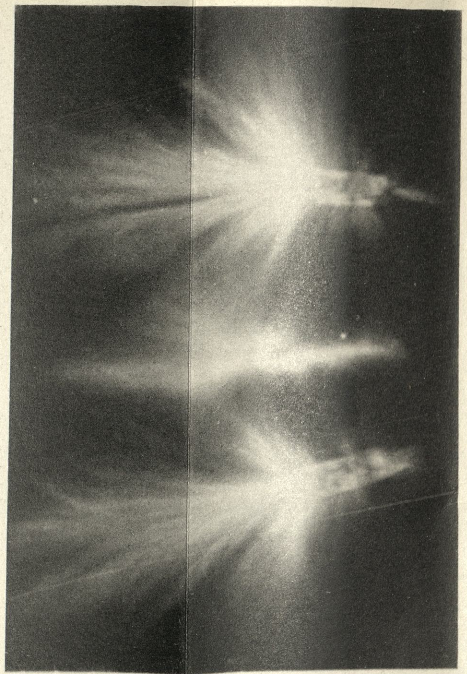

Fig. 25. Wetter-Dynamit, two cartridges of 3.53 ounces each, fired simultaneously.

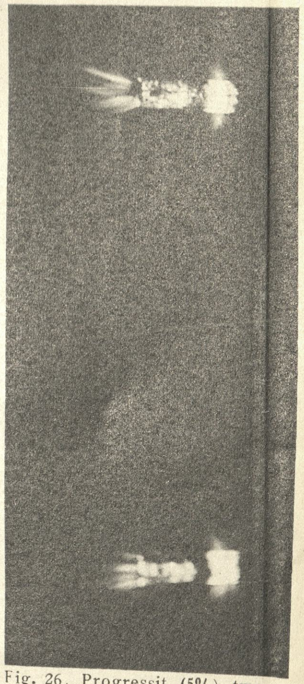

Fig. 26. Progressit (5%), two cartridges of 3.53 ounces each, fired simultaneously.

Fig. 30. Progressit, 10.58 ounces in a cartridge 1.38 inches in diameter.

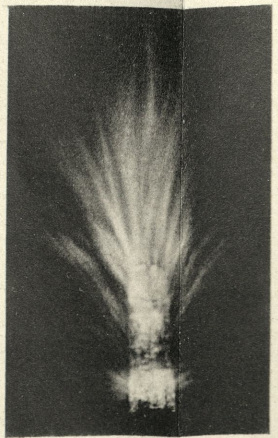

Fig. 31. Progressit, 10.58 ounces in a cartridge 1.97 inches in diameter.

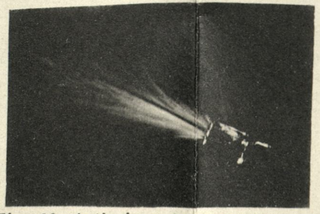

Fig. 32. Antigrisou, 3.53 ounces of a density of 1.20.

Fig. 33. Antigrisou, 3.53 ounces, of a density of 0.90.

Collotype Print by M. Jaffé, Vienna.

Fig. 29. Gelatine-Dynamit, 3.53 ounces stemmed with wet paper, blown-out shot.

Fig. 36. Gelatine Dynamit I, 3.53 ounces at the bottom of the bore-hole with an unstemmed length of 17.72 inches, blown out shot.

Fig. 37. Gelatine-Dynamit I, 3.53, ounces with an unstemmed length of 5.51 inches, blown-out shot.

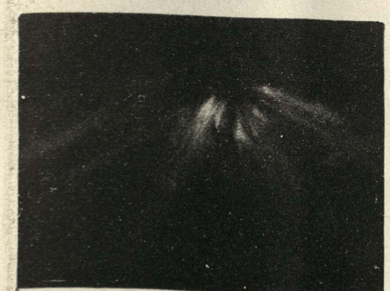

Fig. 27. Guhr-Dynamit, 3.53 ounces in an india-rubber water cartridge.

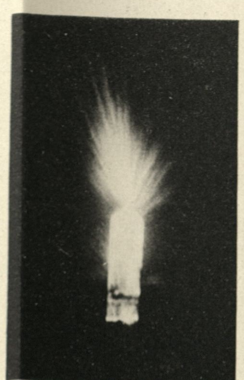

Fig. 34. Roburit with $5^0/_0$ admixture 3.53 ounces.

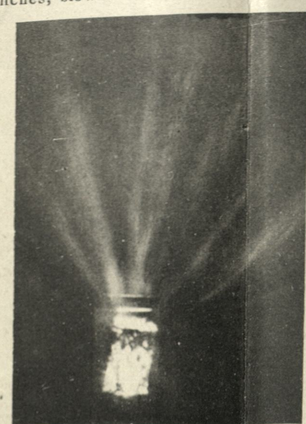

Fig 28. Guhr-Dynamit, 3.53 ounces under water in a glass-beaker.

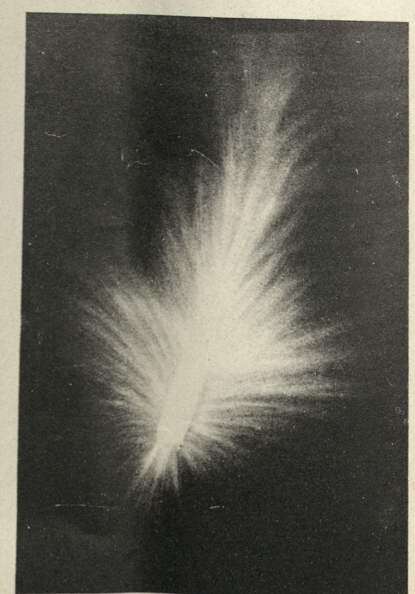

Fig. 35 Grisoutine with admixture 3.53 ounces.

Collotype Print by M. Jaffé, Vienna.

To illustrate Mr. A. Siersch's Paper on "Photography in the Technology of Explosives."

Fig. 38. Progressit, 3.53 ounces at the bottom of the bore-hole, unstemmed, blown-out shot.

Fig. 39. Progressit, 7.05 ounces at the bottom of the bore-hole, unstemmed, blown-out shot.

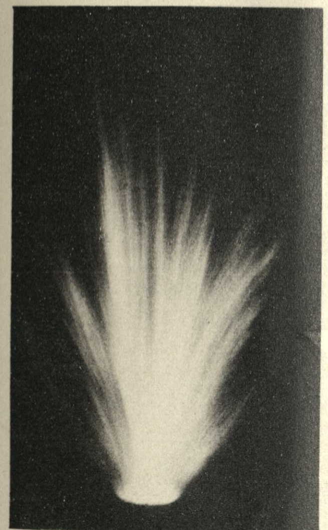

Fig 40. Progressit, 10.58 ounces at the bottom of the bore-hole. unstemmed, blown-out shot.

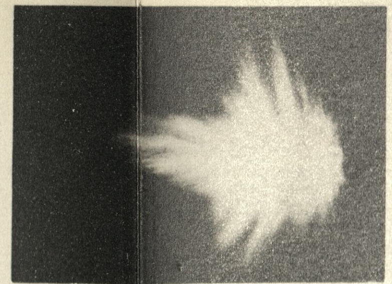

Fig. 41. Nitrate of Ammonium + 6% of carbon compound.

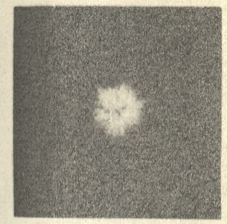

Fig. 48. Progressit, back end of cartridge.

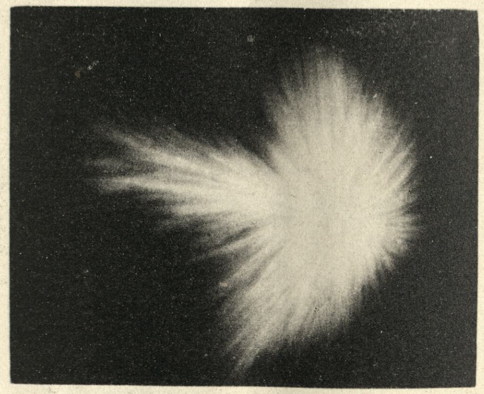

Fig. 42. Nitrate of Ammonium + 8% of carbon compound.

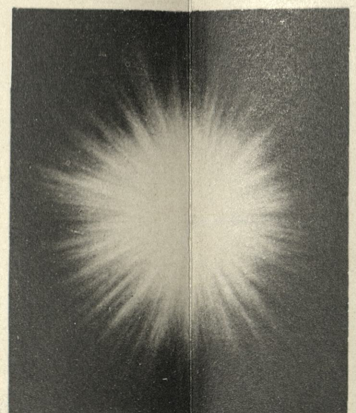

Fig. 46. Roburit, back end of cartridge.

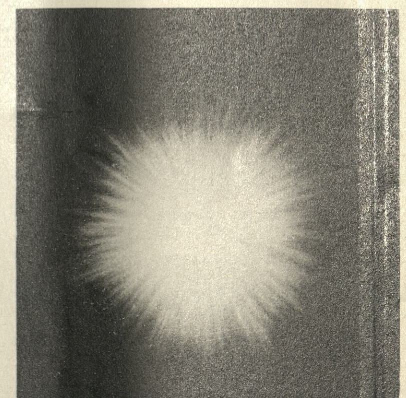

Fig. 47. Wetter-Dynamit, back end of cartridge.

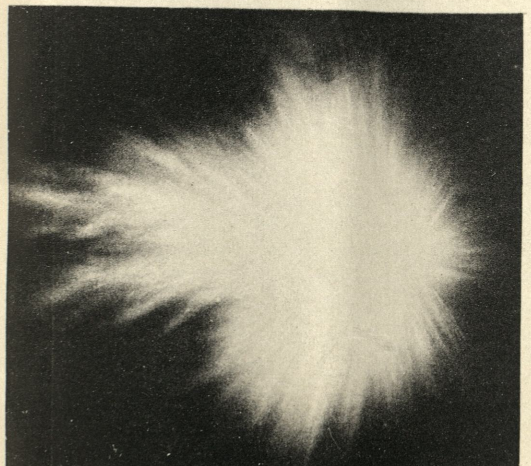

Fig. 43. Nitrate of Ammonium + 12% of carbon compound.

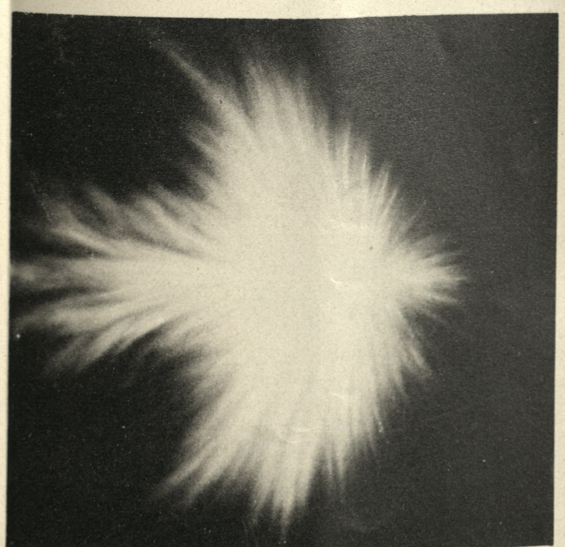

Fig. 44. Nitrate of Ammonium + 18% of carbon compound.

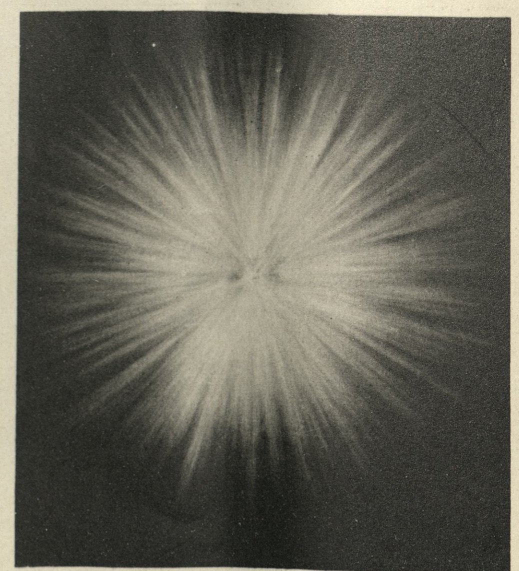

Fig. 45. Gelatine-Dynamit I, back end of cartridge.

Collotype Print by M. Jaffé, Vienna.